Active and Passive Sensing of Sea Surface Friction Velocity

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LONG-TERM GOAL

The long term goal is to develop the capability of polarimetric microwave radiometers to estimate the sea surface wind stress, both the magnitude and direction, and to better understand the physical causes of the azimuthal variation of the sea surface brightness temperature, and its dependence on the air-sea parameters. I also hope to demonstrate the benefits of the integration of active and passive remote sensing to advance our physical knowledge and the skills of radiometry for measuring the air-sea interface. This will add to the scientific foundation for sensors, applications and operational space-based systems, such as the proposed WindSAT.

OBJECTIVES

Using coincident radar (10 GHz) and polarimetric radiometer (37 GHz) measurements acquired from a blimp platform during the COPE 95 Experiment, it is intended to develop a geophysical model function for wind stress, which can be used to invert an azimuthal radiometric signature for this quantity. Physical explanations are sought for the following observations: 1) why does the intensity of the azimuthal variation of the Stokes parameters decrease as the wind magnitude decreases, in contrast with that of the radar cross section whose azimuth variations increases, and 2) are the azimuthal signatures of the Stokes parameters affected by non-equilibrium waves (swell from distant sources) crossing the wind sea obliquely?

APPROACH

The radar and radiometer data was acquired over a span of 12 flights during September and October of 1995, near the Oregon coast. This remote sensing program (Coastal Ocean Probe Experiment) was organized and led by scientists at the NOAA Environmental Research Laboratory in Boulder, CO. I will be collaborating with Dr. Bill Plant (Applied Physics Lab/UW) who developed the radar instrument and conducted the flight measurements, and with Dr. Vladimir Irisov who developed and operated the microwave radiometers. These groups have agreed to grant me access to their data sets and we will collaborate in the interpretation of my results. The instrument characteristics, flight operations, measurements and initial data analysis is presented in the paper by Irisov and Trokhimovski [1996]. The algorithm for friction velocity that will be used to convert the radar cross section data is discussed in [Weissman, et al.,1994] and the application method is discussed in [Weissman, et al.,1997].

At each data run (which usually lasts between 10 to 15 minutes) the radiometer scan is at a constant incidence angle, and the radar observes numerous incidence angles simultaneously (from 35^o to 60^o in steps of 5^o) using a new range-gating approach. The polarimetric radiometer data is processed to yield

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the 2nd and 3rd Stokes parameters, from which their Fourier coefficients (Q_1, Q_2, U_1 and U_2) are computed. A tabulation of the dependence of each of these items on incidence angle and friction velocity will be followed by their interpolation to create a geophysical model function for this instrument with higher resolution.

Additional polarimetric radiometer data (at 37 Ghz) acquired during the Labrador Sea Deep Convection Experiment (March 1997) will be made available to me by colleagues at NOAA/ETL to analyze and combine with the COPE Experiment data. This will be supported with in-situ data of the friction velocity that is being provided to me by the Bedford Institute of Oceanography, who conducted measurements onboard the *RV Knorr*.

WORK COMPLETED

All the available data from the COPE 95 experiment (from the X-band radar and the 37 GHz polarimetric radiometer under favorable oceanic and atmospheric conditions) has been analyzed to create a table showing the dependency of the Stokes "U" and "Q" harmonic coefficients on incidence angle, wind speed and friction velocity.

RESULTS

The first and second harmonic coefficients of the Stokes parameters (Q_1, Q_2, U_1 and U_2) at 37 GHz show a definite variation with both wind magnitude and incidence angle. At a given incidence angle, these coefficients increase with wind magnitude (in the range from 4 to 7.5 m/s). At a given wind speed, I observe that the coefficients are largest at the lower incidence angles (across the range from 17^o to 54^o). These results are comparable to what has been observed by the 19 GHz radiometer (WINDRAD) measurements onboard a DC-8 aircraft in 1993. However, the COPE data collection is small and additional data is needed to place more confidence in these interpretations.

IMPACT/APPLICATIONS

These results contribute to the knowledge base needed to advance our physical understanding of how these millimeter polarimetric radiometers respond to air-sea parameters, and to the development of space based multi-frequency, multi-look and multi-polarization passive sensors.

RELATED PROJECTS

This work is associated with the radar remote sensing program of Dr. William Plant of the Applied Physics Laboratory/University of Washington. The radiometer data has been provided by Vladimir Irisov of the NOAA/ETL, Boulder, CO. The interpretations of the joint active/passive observations and results are performed in close collaboration with these colleagues.

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